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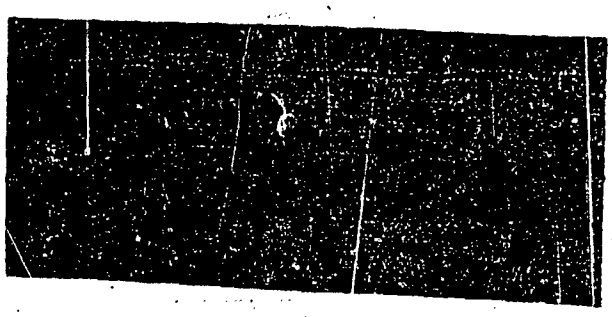

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U. S. DEPARTMENT OF THE INTERIOR

SOIL EROSION SERVICE

ENGINEERING PHASES OF WORK

ON S. E. S., NAVAJO PROJECT

Submitted by

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UNM 4787

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INTRODUCTION.

Project Number 10 of the Soil Erosion Service called "Navajo Project" covers the Navajo Reservation located in northeastern Arizona, Northwestern New Mexico and southern Utah. The land is entirely Federally controlled and the Project is not concerned with the usual land ownership problems. On the other hand it is concerned with many unique problems which arise from dealing with a primitive nation whose language, customs and habits of thought are different from our own.

The purpose of this paper is to discuss these problems, especially in relation to the work of the Engineering Division. For a perfect understanding of the work involved it will first be necessary to give a brief description of the region under treatment, thus indicating in general the problem and its solution. The main discussion will cover those engineering phases involved in the present work on our so called "Demonstration Areas."

DESCRIPTION OF AREA.

GENERAL.

The Navajo Reservation comprises approximately 17,000,000 acres of land, bounded on the south by the Little Colorado and Puerco Rivers, on the west by the Little Colorado and Colorado Rivers, on the north by the San Juan River and on the east by the 108th meridian.

The average elevation of this region is close to 5,500 feet varying from 2,800 feet to 10,400 feet.

The annual precipitation varies from over 15 inches to less

UNM 4788

CV-6417-201 NN006604

than 5 inches with a probable average of 9 inches. The seasonal distribution is poor with 40% occuring during the months of July, August and September and less than 12% of the total during April, May and June. The storms, in the months of greatest rainfall, are of the thunder shower type with duration usually of less than an hour.

A prevailing wind from the southwest plays an important role in changing the land conditions over the Reservation.

Two types of soil are to be found on the Reservation, namely, residual and transported. The latter type predominates because of the nature of the precipitation, scant vegetation and strong prevailing winds.

VEGETATIVE CONDITIONS.

The seasonal distribution of precipitation, the temperature, and type soil all tend towards a vegetation which is adaptable to range use or leads to the raising of livestock as the principal industry. While grazing under proper control is not necessarily harmful to the vegetative cover, yet under the conditions as found today and probably prevalent since 1890, the range is greatly overstocked. Excessive and uncontrolled grazing have resulted in severe vegetation depletion.

As the period of least rainfall from April to June is also the growing season for most crops it is apparent that productive agriculture is quite a problem. Proper farming under flood irrigation appears to be the type most likely to succeed on any large scale over the Reservation.

Not over 5% of the land in the Reservation is covered with saw

UNM 4789

CV-6417-201 NN006605

timber species. Possibly 20% of the area is covered with pinon and juniper but due to overgrazing, reproduction is lacking over possibly 90% of this area.

EROSION CONDITIONS.

Except for the timbered areas in the higher altitudes and small protected tracts, erosion is generally evident in some form over the entire Reservation. While sheet erosion is present, yet due to its advanced stage "Gully erosion" as indicated by thousands of miles of arroyos, ranging from 10 to 100 feet deep, assumes major significance. Channel beds in many sections are rapidly cutting deeper, and present intermittent gullies soon promise to form one continuous arroyo unless controlled. In other sections the bed of the stream is stablined but broad valleys are being threatened through lateral cutting. Soil swept away is being spread over potential farm lands or deposited in reservoirs along the rivers.

Wind erosion is also quite general and many slopes have been swept clear of all their soil cover, leaving bare the roots of shrubs and trees. This same blow sand is burying other vegetation and the sand dunes are constantly on the move.

As indicated the main cause of erosion throughout this region is the destruction of the vegetative cover by overgrazing. Highways, wagon roads, stock trails and improper cultivation are also contributing factors.

It must be understood that the term "erosion" as used herein

UNM 4790

CV-6417-201 NN006606

means an accelerated process due to human action, rather than the gradual carving of the landscape brought about by geologic and climatic influences.

THE PROBLEM AND ITS SOLUTION.

From the above description it may be noted that the condition of the land in the Reservation is very serious. The Navajo tribe is increasing and today approximately 46,000 are attempting to exist on this land with livestock as the main industry. As it is impossible to consider moving the Indians to new lands, the problem facing the Soil Erosion Service is mainly the protection and preservation of the remaining valuable land.

Proper land use methods in order to protect and increase in density the vegetative cover appear to be the only logical solution. This statement would first seem to place the work in the hands of the range examiners and foresters rather than in those of the engineers, except as roads and trails cause erosion; but the term "vegetative cover" is in reality an engineering term as its purpose is to protect the underlying soil from the action of the elements in much the same manner as an engineer uses the asphalt covering to protect the road bed from the erosive action of the wheels of traffic. It is quite true that possibly forty or fifty years ago the solution of the problem would have concerned only the range examiners and foresters but today with erosion in an advanced stage those Divisions must necessarily call to their aid the engineers, soil experts and agronomists.

UNM 4791

CV-6417-201 NN006607

As all phases of erosion control are involved in the solution of the problem each Division has its special work. Proper range control with the number of livestock reduced to the estimated carrying capacity is the objective of the Range Management Division. This same control will permit reproduction in the timbered areas. The agronomist is interested in the reseeding of certain areas, and proper farming methods in order to increase the yield from agricultural land and to protect the same from erosion. The soil expert indicates the proper land use for the various types of soil.

The engineer must have a general understanding of all the above phases in order to better correlate them with whatever engineering work is required to round out the program. For example it would be useless to attempt the building of a number of structures to hasten revegetation of the land unless it is possible to secure proper grazing control to protect the vegetation. It would also be useless to build structures in an area where the soil is not suitable either for their construction or for revegetation.

Many of the engineering phases involved, such as map compilation and detailed surveys to supplement aerial maps, are similar to those encountered on other projects and the attempt hasbeen made to hold the discussion to those common more or less to this one Project. The main portion of the present engineering work is confined to certain selected areas where methods of artificial control are being demonstrated to the Navajos and it might be said to the engineers as well. Some of the problems which arise are really perplexing as will be noted later.

UNM 4792

CV-6417-201 NN006608

DEMONSTRATION AREAS.

The need, purpose and results obtained from engineering structures, range control, and proper farming methods must all be clearly demonstrated to the Navajos before they may be expected to accept the final plans as applied to their 17,000,000 acres of land.

This demonstration may best be accomplished through establishing a number of selected areas, well distributed over the Reservation, upon which all phases of proper land use may be practiced. At the present time there are approximately ten of these areas, varying in size from eight square miles to 67 square miles, under treatment. The majority of these are of the general demonstration type but one or two may be termed "Cooperative Areas" where those Navajos receiving direct benefits are expected to contribute, without pay, to the work.

Each of these areas is covered with an agreement whereby the inhabitants permit the area to be fenced and placed under the control of the Soil Erosion Service for the period of the agreement. This allows regulation of grazing and farming methods.

Before discussing in detail the engineering work involved on the area it is best to illustrate the general conditions by a description of a typical cross section. This would show a fairly flat slope at the divide, a steep slope from the break to the valley floor, and a slight fall from here to the main arroyo. The area at the divide and the valley floor at one time contributed the best range land on the Reservation but are now cut up badly by gullies fingering out from the main arroyo. The steep slope often consists of rock, swept bare by the

UNM 4793

CV-6417-201 NN006609

forces of wind and water. The main drainage often consists of intermittent gullies which promise to form one continuous arroyo unless controlled.

ENGINEERING PHASES OF WORK ON THE AREAS.

The engineer is by training equipped to supervise engineering construction and with even a limited knowledge of agronomy, forestry and soils, he is the logical man to place in supervision of these areas. As such he is called "Project Engineer" and may have charge of one, two or three areas. Under him and in direct supervision of each area is a Project Manager who has complete charge of construction and as a rule is the only white man on the job, the others all being Indians.

The engineer is first concerned with a map of the demonstration area. The entire Reservation has been covered with an aerial survey and it was hoped that through the use of this and small supplemental surveys a suitable map could be prepared of the individual areas. There has been a delay, however, in securing the mosaics covering most of the demonstration areas and it has been necessary to proceed in many instances without maps other than reconnaissances. In the future, however, a map will be prepared which indicates main drainages, cultural features and well defined ridges and breaks of slopes. A contour map is made only where required for a special structure layout.

The engineer in charge of the area is expected to correlate the plans and recommendations of each Division with those of Engineering into one "Area Working Plan." The area is divided into sub-areas, each

UNM 4794

CV-6417-201 NN006610

consisting of one or more complete drainages and the Working Plan deals with them as units.

In the engineering treatment of the areas there is a danger, in this country at least, of misleading the Indians as to the value of proper range control and farming methods by too great a concentration of structures. For this reason only those sites are selected at which it appears that the maximum amount of good may be accomplished.

Since the proper sequence of all erosion control work should be from the upper limits of the watershed down the drainage, therefore, any work accomplished on the gentle slopes at the divide really serves the dual purpose of aiding the return of vegetation in the section concerned as well as protecting the land below from water and silt. The nature of the required treatment is that which will detain or spread the flow of water. This is accomplished by a number of impervious dikes or contour furrows well distributed over the area, giving the appearance of several small reservoirs. As the slope steepens(up to 3 or 6%) these impervious dikes are replaced with weepers or spreaders, on the contour, the purpose of which is to retard the runoff by causing a slow even spill or seepage, and thus doing away with the danger of concentration. Across the gullies in all cases impervious diversion dams should be built.

The earth dike or dam is usually the most economical but in certain sections of the country with a low rate of precipitation careful consideration should be given to the disturbing of a vegetative cover which is difficult to replace. Low brush or rock dikes also make ideal detention or spreading works. An economical dike for

UNM 4795

CV-6417-201 NN006611

temporary purposes is the one constructed of burlap sacks filled with soil. The woven wire fence backed with brush or burlap has been used to detain and spread the water with great success.

As a rule, the steep slopes are left untreated as more harm may result than good. An exception is made in the case of active gullies where a few low check dams may control further cutting.

The valley floor in this country presents many major problems to the Engineering Division as it is here that the agronomist and range man need aid. At the present time practically all benefits from the precipitation are lost, as the runoff is rapidly carried away through a system of gullies and artificial control is required in order to take the water out of the arroyos and spread it slowly over the land. This requires diversion dams, dikes and spreaders. The type of dam depends mainly on the watershed above, as with a small runoff the entire amount may be diverted but with a larger runoff a center spill type of dam is needed with a diversion of only a portion of the flow. The materials of construction depend on the use of the structure as well as availability of material. Earth, rock, brush, concrete or masonry, wire and rock or brush, timber and sacks, treated or untreated, filled with earth or cement indicate many of the common types of dams.

The engineer is inclined to overlook the importance of the drainage area above a structure especially if it happens to be a small dam. He is also likely to use the present gully and high water marks as a guide without realizing that at times the banks have been overtopped. The methods of correct design can only take into account the area of watershed and its nature. In those sections of the country where the

UNM 4796

CV-6417-201 NN006612

relation of runoff, precipitation, slope and vegetation has been determined this is an easy matter but this region is unfortunate in not having at present any such relation and until it is determined common sense alone must be the guide in design of structures. Other precautions which must be taken in the design of these dams, especially those of earth, where puddling is prohibitive, are core walls, deep cutoffs and sloping of the banks preliminary to construction.

After diversion from the gully the water must be spread over as large an area as possible in order to delay its return to the channel and hasten the revegetation of the land through irrigation. The spreader structures are built either on the contour or a slight grade depending on their type or amount of runoff. The impervious dike is used to carry the water away from the banks where it may be spread by means of low rock or brush dikes, low woven wire fences backed with burlap or brush or low sack dikes with small openings for seepage. These spreaders should be staggered and spaced so that the water has no chance to become concentrated and, therefore, cause gullies.

The points of diversion should be carefully selected remembering that silt as well as water will be spread and in order to aid revegetation this depth of silt must not be excessive.

Another problem confronting the engineer and perhaps the paramount one in this country is that of controlling active head and lateral erosion. It is hopeless to expect vegetation, even under perfect grazing control, to keep pace with this erosion until it has had a chance to attain its growth and thus the engineer must provide some means of artificial control.

UNM 4797

CV-6417-201

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The type control depends on many factors such as drainage area, soil, vegetation and topography but in general may be divided into three classes, diversion, centrally built drop structures or sloping of banks.

In this country the best method, where it can be used, has been the diversion of the runoff by means of an impervious dike just above the point of active erosion and the spreading of ~~it~~ the water before it returns to the arroyo. By diverting the flow, the arroyo has a chance to heal and revegetate and through spreading, revegetation is hastened. This method, however, is only possible where the runoff is not excessive and the valley broad enough for spreading. Small local drainages are often responsible for lateral erosion and it has been found possible to stop the same by placing a low level dike on the bank of the arroyo which provides a slow even spill and does away with any concentration.

Where the topography does not permit spreading or the runoff is too great then the water must be dropped into the arroyo through one central structure and thus alleviate further head erosion. Depending on the permanency required these structures may be built of concrete, masonry, sacks filled with cement and sand, wire and rock, asphalt emulsion and aggregate, timber, wire and brush, and brush.

Experiments are being made on these areas to determine the actual value of artificial sloping of the banks of an arroyo, followed by revegetation, in this country with a poor seasonal distribution of rainfall. Various slopes as well as different types of vegetation and methods of planting will be compared with untreated slopes in adjacent

UNM 4798

CV-6417-201

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arroyos in order to determine the value of the treatment.

The tracts of land, selected by the Agronomy Division for demonstration of proper farming under flood irrigation, are in general located in the valley floor. The design and construction of the necessary training dikes, emergency spillways and diversion dams are the concern of the Engineering Division.

The main arroyo offers a difficult problem to the engineer and he should carefully study its characteristics before attempting its treatment. As a rule this treatment should not be undertaken until all drainages above have been placed under control. The arroyos may be divided into two classes, those which are continuing to cut deeper and those which are stabilized as to bed but cutting laterally.

In the first class low check dams are necessary to stop further cutting and to provide silt beds for planting. These cross structures must be carefully designed to take the total discharge of the channel.

In the latter class trees and shrubs are planted along the foot of the bank to control side cutting and these must be protected by artificial means until they obtain their growth. The required structures consist of jetties, dikes and fences.

With few exceptions it may be noted that all structures mentioned in this discussion may be classed as temporary, in that they are to act only until such a time as vegetation replaces them. The Agronomy Division has charge of the seeding of structures which will act as centers for future vegetative spread.

The matter of records is very important in order that relative

UNM 4799

CV-6417-201 NN006615

costs of different sub-areas or units may be compared and results noted. These same records also indicate the cost of a few typical structures for future estimating.

The photograph gives an ideal record and, therefore, stations have been established over all areas from which the views may be taken at certain intervals of time. These stations are marked on the field and located on the maps.

MISCELLANEOUS ENGINEERING PHASES.

The concentration of runoff caused by highways, wagon roads and stock trails, due to overgrazing, has resulted in much of the erosion as found on the Reservation. The treatment of existing roads, used and discarded, as well as of future roads, is necessary and part of the engineer's problem. This treatment in general consists of proper drainage and spreading of water so as to stop undue concentration. Policies governing this phase are being drawn up and will be given to all road building agencies on the Reservation.

Another phase is that of engineering training. The range examiner, soil expert, and agronomist each have trainees working with them and on the crews the engineer and manager are training leaders and foremen. The Engineering Division has lately undertaken the instruction of a small group of Navajos in engineering, such as surveys, map making and layout of erosion control structures.

The various engineering phases just discussed will be applied to the Reservation as a whole when final treatment plans are undertaken. This will be after the completion of the grazing and soil surveys of the Reservation.

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CONCLUSION.

In conclusion a few of the rather perplexing questions which require answering on this Project are stated in the hope that a discussion of the same may be started.

1. What is the most logical method of estimating the economical concentration of engineering structures in range country?

2. To what degree should the use of large machinery be permitted on engineering work on the Reservation?

3. To what extent should the need for employment effect economical erosion control work?

UNM 4801

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